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Translations of Portions of 304-Page Textbook by:

John A. Kerr, Research Engineer, Dept. of National Health and Welfare, Public Health Engineering Division, 541 Federal Building, Edmonton, Alberta, Canada.

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CHAPTER 3

COLLECTION AND REMOVAL OF FLUID WASTES

1. General Principles

When new communities and workers' settlements are to be constructed, problems concerned with the organization of public sanitary engineering facitlities are resolved at the same time that the planning of the layout and buildings is done.

In modern times plans are made for an integrated community sewage collection system for the removal of fluid wastes in the majority of cases.

An integrated sewage collection system is not constructed, however, in sections of communities with low building densities and/or isolated buildings (hospitals, sanitoriums, some dwellings, etc.). In these cases small local treatment works or individual receptacles for fluid wastes are constructed. Cesspit evacuators remove fluid wastes from individual receptacles and transport them to discharge points or discharge stations or to treatment and utilization fields.

Fig. 35 illustrates methods used for the treatment and utilization of fluid wastes.

It should be noted that sewage can only be discharged at discharge points and stations when it is subsequently carried to treatment facilities in a sewage collection system.

2. Collection and Removal of Fluid Wastes from Unserviced Areas

Fluid wastes from unserviced buildings consist of sewage (fecal matter and urine) and slops. Fluid waste design criteria with respect to quantity and composition are given in Tables 10 and 11.

Sewage from unserviced areas is collected in toilets and in cesspits connected to toilets.

Lavoratories have anti-epidemiological, sanitary, human, cultural and economic features; the following requirements are compulsory:

a. Epidemiological: flies must not have access to the wastes;

b. Sanitary: the wastes must not contaminate adjacent soil, water, air and residences;

c. Human: lavoratories must be warm, easily accessible and comfortable;

d. Cultural: lavoratories must always be immaculately clean;

e. Economic: sewage must be used as fertilizer for the soil, as a rule.

These requirements must be strictly followed when constructing lavoratories.

The following types of lavoratories are constructed in unserviced areas:

a. Ventilated toilets with cesspits;

b. Outdoor toilets with cesspits;

c. Fixed or portable toilets with sliding, removable or fixed receptacles.

In cases where separate buildings or groups of buildings have a water supply but cannot be connected to a community sewerage system, small local purification works are built.

Ventilated Toilets with Cesspits (Fig. 36)

This is one of the most ideal designs for receiving fluid wastes from isolated buildings which have neither a waterworks nor a sewerage system. The toilet is placed inside the building (adjacent to the exterior wall) and hence can be conveniently used during all seasons of the year. The minimum dimensions (in plan) of the one-window compartment housing the toilet are 90 x 120 centimeters. The compartment should have a separate entrance, should receive daylight, and should be heated from the kitchen side. The toilet bowl (1) is set on the floor and has a seat with a hole and a cover (2). It is not provided with a hydraulic shut-off device. The bowl can be enamel, cast iron, earthenware or ceramic. Sewage enters the cesspit via an outlet tube attached to its base. The outlet tube is 150 centimeters in diameter. The length of the outlet tube is governed by the rule that its base must not be less than 20 centimeters below the cover of the cesspit.

The cesspit (3) is always installed below the surface of the ground. It must be impermeable. The construction of prefabricated, reinforced-concrete cesspits is recommended. Special measures (such as electolytic iron plating, waterproofing, etc.) must be adopted to prevent the infiltration of ground water and the seepage of wastes into the ground. The cesspit is often isolated from the ground by a layer of rich, well-compacted clay (4) from 30 to 35 centimeters thick. The capacity of the cesspit is a function of the the number of persons it is designed to serve. The covered hatch (5) is opened when the cesspit is emptied; the cover is placed from 10 to 12 centimeters above the surface of the ground and surrounded by fill.

The principal feature of this type of toilet is that it can be suitably ventilated by attaching the cesspit vent pipe to the flue of the heating unit. The vent pipe should be 0.5 meters higher than the flue of the heating unit and should be provided with a deflector at its upper end. As the toilet's ventilation conduit is situated adjacent to the flue of the heating unit (8) which is always warm, a good draft is assured. Air from the cesspit and the compartment housing the toilet moves along the horizontal conduit and up the vertical conduit to the outside.

The cesspit must be emptied at least 3 or 4 times per year.

The capacity of the cesspit is determined from the formula

$$W_v = \frac{1.3 q_n N}{n}$$

where W_v - Capacity of the cesspit, in cubic meters;

q_n - Maximum volume of sewage in cubic meters per person per year;

N - Number of residents using the cesspit;

n - Number of times cesspit is emptied per year;

1.3 - Reserve volume coefficient for cesspit.

In the absence of a sewerage system, this type of toilet should be widely used both for dwellings and for small institutional buildings such as schools, children's institutions, hospitals,etc.

Example. The capacity of a ventilated toilet cesspit is required; there are 20 persons in the dwelling contributing 600 liters of sewage and 400 liters of slops per person per year. Assuming that the cesspit will be emptied four times per year, the capacity of the cesspit is:

$$W_v = \frac{1.3(0.6 + 0.4)20}{4} = 6.5 \text{ cubic meters.}$$

Outdoor Unheated Toilets With Cesspits (Fig. 37)

Outdoor toilets for isolated dwellings are frequently of the unheated type. They are permissible from a sanitary point of view if they are properly constructed. They have an underground cesspit (1) and aboveground toilet facilities (2).

The cesspit is made impermeable. Its capacity is computed in the same way as the cesspit of a ventilated toilet. The cesspit is emptied at least once per month.

The aboveground section must have a pleasing exterior appearance and must be flyproof, with no cracks, a tight self-closing door, pane glass openings, and screen covers for units without roofs. The cesspit and the aboveground compartments are ventilated by a duct which is extended from 0.5 to 1.0 meters above the crest of the roof; the top of this duct should also be covered by a screen to prevent flies from entering the compartments.

Outdoor toilets are built at distances of not less than 15 meters from dwellings and public buildings, and not less than 20 meters from adjacent water wells. In the latter case special care should be taken to make the cesspit waterproof.

Bucket Toilets

Bucket toilets have some application under low population density conditions. They can be either fixed or portable with sliding, removable or fixed receptacles. Bucket toilets are frequently used in localities where wastes can be composted on the personal plots of collective farms or placed directly in the ground.

A bucket toilet has its own waste receptacle. Material with a high moisture capacity which is capable of absorbing the

fluids and gases which can be separated from the sewage is placed in the receptacle with the wastes.

The simplest type of construction is the bucket toilet shown on Fig. 38. The receptacle of this unit has a capacity of from 21 to 25 liters and is placed under a bench with a cover. Such units have not been widely used in the U.S.S.R. Bucket toilets are still used in modern times in some cities of Germany, Denmark and the Scandinavian countries. Bucket toilets are generally installed in premises where flush toilets are planned for the future. Dry peat, soil and ashes are frequently placed in the bucket with the wastes. Peat is the best material for this purpose.

When a container is emptied once per 24-hour period and when 4/5th of its capacity of 20 liters is filled, it can accomodate:

$$(20 \times \frac{4}{5})/(2.8 \times 0.83) = 7 \text{ persons},$$

where

2.8 liters - Volume of peat per person per 24-hour period;

0.83 - Residence coefficient for the family.

One person produces 1.4 kilograms of sewage in one 24-hour period, on the average. The weight of peat added is assumed to be 1/5th of the weight of the wastes, or 1.4/5 = 0.28 kilograms per person per day. As the specific weight of excavated peat is 0.1, the corresponding volume is 2.8 liters of peat per person per day. This volume remains constant as added wastes are absorbed by the peat.

The residence coefficient for the family is computed in the following manner. If half of the total number of members in

the family are at home during the entire 24-hour period and the other half are at home during two-thirds of the 24-hour period (at work for 8 hours), the average daily residence per person in the family is:

$$100(1 + 0.66)/2 = 83\% \text{ of one 24-hour period.}$$

After the container has been emptied peat is sprinkled on its walls and a layer of peat from 10 to 12 centimeters thick is placed on its bottom. Carrying the bucket out generally presents no difficulties as it does not weigh more than from 12 to 14 kilograms. The material which is added is generally stored in a special 40-liter container. The latter volume is computed from the utilization time (three days when soil is added and five days when peat is added).

Outdoor Toilets With Fixed Receptacles (Fig. 39, a & б)

This type of installation does not have to be emptied as frequently as a bucket toilet. Its principal disadvantage is the inconvenience caused by the distance between the toilet and the living premises. The quality of the work must be high when constructing such a toilet so that flies will not have access to the wastes. The waste receptacle (1) must be constructed from planks from 4.5 to 5.5 centimeters thick set on an impermeable pad (2) of rich, well-compacted clay or concrete. Wastes are removed after opening a cover (3). The volume of the receptacle is approximately 350 liters.

When an outdoor toilet with a 350-liter fixed receptacle is used by a family of seven, it must be cleaned every

$$(350 \times \frac{2}{3})/(2.8 \times 7 \times 0.83) = 14.3 \text{ days.}$$

It is best to place the wastes which are removed from the receptacle in a compost pile which can be located near at hand. They can also be placed directly in a kitchen garden or orchard and covered with a layer of soil. A storehouse for storing the wastes is constructed next to the toilet. The structure is 1.4 x 1.4 meters and is sheeted with quarter-beam or grooved planks to prevent the entrance of water.

Outdoor Toilets With Sliding Receptacles (Fig. 39, B)

These toilets have smaller receptacles (130 to 140 liters). Runners or wheels are placed on the receptacle to facilitate its removal and replacement. A 140-liter receptacle for a family of seven must be emptied every

$$(140 \times \frac{2}{3})/(2.8 \times 7 \times 0.83) = 6 \text{ days.}$$

The sliding receptacles are generally made of wood and waterproofed by impregnation with special anti-rot compounds. Metal containers, painted to prevent corrosion, can also be used.

Waste Pits

As has already been pointed out, up to 2 cubic meters of slops per person per year are produced in unserviced areas. The removal of all of such a large volume of fluid wastes would require a large equipment outlay. It is thus expedient to discharge slops onto filtration areas on personal plots of collective farms and to utilize the natural self-purification capacity

of the soil. Slops are also placed in compost piles.

These measures considerably reduce the amount of slops to be removed.

Waste pits (Fig. 40) are built to collect and temporarily store slops until they are removed.

Waste pits are made of concrete, brick and wood. The principal criterion with respect to good workmanship is impermeability. Waste pits have below-ground and above-ground sections. The former section (1) is used for the storage of slops. The latter section (2) consists of a manhole with interior screens and a cover. The screens are wooden bars which retain large solid bodies in the wastes. These bodies are removed and placed in ordinary garbage cans. Waste pits are built to serve dining rooms, restaurants and residential areas with a large number of habitations.

The below-ground section of the waste pit shown on Fig. 40 is built of concrete. The pit is first lined with clay to ensure that it is impermeable. Slops must be removed not less frequently than from 6 to 12 times per year.

Removal of Wet Wastes

Wastes from the cesspits of ventilated and outdoor toilets and from waste pits are periodically removed and transported to waste discharge stations, sanitary fields, etc. The vehicles which carry out these operations are known as cesspit evacuators.

The following sanitary rules must be observed during the above operations:

a. The adjacent area must not be contaminated when the tank is being filled with wastes;

b. Tanks and receptacles must be watertight and their outside surfaces must be clean;

c. The loading and unloading hatches must be tightly closed when travelling to prevent the escape of foul-smelling gases;

d. The workmen operating the vehicles must have suitable overalls.

The operations of removing and transporting sewage and slops must be mechanized as far as is possible. There is still much to be done in this direction, however.

At the present time, fluid wastes are collected and transported in horse-drawn and motor vehicles of the following types:

a. Fluid tanks;

b. Cesspit evacuators with pumps;

c. Cesspit evacuators without pumps.

Fluid Tanks (Fig. 41) are generally horse-drawn. A 500-liter tank is drawn by one horse and a 1,000-liter tank by two horses. The tank is filled through the upper hatch (1) and

emptied via the lower hatch (2). This type of unit has sanitary, technical and economic disadvantages. When buckets are carried by hand, the workers inevitably come into contact with the wastes and the surface of the adjacent area is contaminated.

Cesspit evacuators are classified as cesspit evacuators with pumps and cesspit evacuators without pumps. Both are mounted on the chassis of heavy vehicles. The tank is filled by a pneumatic system which creates a pressure difference between the exterior atmospheric pressure and the vacuum pressure inside the tank.

In the case of cesspit evacuators with pumps, the vacuum in the tank is created by a vacuum pump; in the case of cesspit evacuators without pumps, the vacuum is created by the motor of the vehicle.

A cesspit evacuator with a pump (Fig. 42) consists of a tank (1), a vacuum pump and a power selection casing. The unit operates in the following manner: The end of the intake hose (2) is dropped into the cesspit, a knife-edge shutoff device on the intake sleeve is opened and a fourway valve is set at the "full" position. The suction line of the vacuum pump (3) is connected to the tank (1). The vacuum pump, driven through the power selection housing, creates a vacuum in the tank which is then filled with wastes. The knife-edge shutoff device is closed after the tank is filled, the power selection casing is disengaged, and the fourway valve is placed at the "neutral" position, which isolates the tank from the pump. The end of the intake hose is removed and placed on a bracket at the side of the tank.

When the wastes are discharged from the tank, the hose is placed in a manhole or a trough, the knife-edge shutoff device is opened and the fourway valve is set at the "empty" position which connects the tank to the pump discharge. When the power selection casing is engaged the vacuum pump starts, supplying air under pressure to the tank which causes the tank to be rapidly emptied.

A cesspit evacuator without a pump is distinct from a cesspit evacuator with a pump in that it does not have a vacuum pump, a power selection casing and an oil pan. The fourway valve is replaced by two valves - a threeway valve and a twoway valve. An additional gas selection housing is installed on the main exhaust line from the motor.

In this type of unit the tank is filled under the action of a vacuum created in the intake manifold of the motor and emptied under the action of pressure in the exhaust manifold of the motor.

The technical characteristics of cesspit evacuators are given in Appendix 6. These units are widely used in the U.S.S.R.

The above-described cesspit evacuators are also used for removing fluid wastes with a high moisture content (96% and more). This increases operating costs considerably. The problem of removing consolidated sludge from cesspits has not yet been completely solved. In the future it is necessary to develop equipment with moisture separators, equipment with mechanisms for removing consolidated sludge, and storm water systems.

Some work on the development of equipment to remove consolidated sludge has been carried out by the A.K.Kh. Scientific Experimental Institute.

The Ilosos L.N.I.I. A.K.Kh. (I.L.-Z.I.L.-585) unit (Fig. 43) is mounted on the chassis of a Z.I.L.-585 dump truck. It is made up of a tank (1) with a capacity of 2 cubic meters, a metal tube (3) which is placed in the receptacle, and a rubber hose (2) between the tank and the metal tube. A compressor (4) creates a vacuum in the tank.

The unit also possesses a water separator and washing equipment. Technical characteristics of the unit are given in Appendix 6-B.

The removal of sludge from the manholes of a sewage collection system and from cesspits by manual methods in a labor-consuming operation which must be carried out under unsanitary conditions; the introduction of equipment described above in practical work is thus urgent.

An experimental model of this type of unit is being fabricated and tested in Leningrad at the present time.

APPENDIX 6

A. BASIC DATA ON TECHNICAL CHARACTERISTICS OF CESSPOOL EVACUATORS

Designation	Unit	Ts.N.-15	A.S.M.-1	A.S.A.-2
Vehicle Chassis	Model	Z.I.L.-5	Z.I.L.-5	G.S.Z.-51
Tank Capacity	Liters	2,500	2,300	2,100
Vacuum Pump	Type	R.N.-6	None	None
Maximum Depth of Cesspit	Meters	5.0	3.5	3.0
Tank Filling Time	Minutes	2.0	3.0	3.0
Tank Emptying Time	Minutes	3 - 4	4 - 6	1.5 - 3
Working Pressure in Tank During Emptying	Atmospheres	2.0	1.5	1.5
Weight of Unloaded Equipment	Kilograms	3,650	3,330	2,330
Weight of Loaded Vehicle	Kilograms	6,150	5,630	5,145
Travelling Speed	Kilometers Per Hour	35	35	35
Fuel Comsumption:				
To Fill Tank	Liters	0.8	0.8	0.8
To Travel 100 Kilometers	Liters	34	34	26.5
Overall Dimensions:				
Length	Millimeters	5,850	6,680	6,100
Width	Millimeters	2,185	2,185	2,100
Height	Millimeters	2,100	2,250	2,300

B. BASIC DATA ON TECHNICAL CHARACTERISTICS OF ILOSOS I.L.-Z.I.L.-585 MODEL L.N.I.I.A.K.Kh.

Designation	Unit	Value
Load Capacity	Kilograms	3,500
Sludge Tank	Cubic Meters	2.0
Water Tank	Cubic Meters	0.6
Total Weight of Unloaded Vehicle	Kilograms	5,410
Normal Compressor Speed	Revolutions Per Minute	950 - 1,100
Compressor Capacity	Cubic Meters Per Minute	2.2 - 2.5
Highest Vacuum Created by Compressor	%	80
Compressor Power Requirement	Horsepower	12
Maximum Sludge Suction Height	Meters	6.3
Time To Create 75% Vacuum in Tank	Minutes	1.5
Overall Dimensions:		
Length	Meters	6.3
Width	Meters	2.4
Height	Meters	2.6

Waste Discharge Points and Stations

The utilization of sewage collection systems in connection with the removal of fluid wastes from unserviced buildings and areas has for many years attracted the attention of those working in the municipal utilities field.

In Moscow, in 1919-20, a system of small waste discharge stations, supplementary to the large waste discharge stations and dumping grounds, was organized inside the city, based upon designs by A. V. Nikitin.

Waste discharge points and stations are designed as sanitary engineering structures and installations for receiving fluid wastes and discharging them into a sewage collection system. Slops from outdoor waste pits and sewage from cesspits are discharged at the waste discharge points and stations.

In the treatise by G. G. Shigorin (Ref. 17), it is recommended that 600 kilograms of sewage per person per year be used as a design criterion and that correction factors be introduced to take the shape of receiving receptacles and population increases into account. In designing cesspits it is assumed that 600 kilograms of sewage per year is produced by a person more than 18 years of age; recommended age correction factors are 0.2 for up to 7 years of age and 0.6 for from 8 to 18 years of age.

The above design figures are reduced by from 20 to 35%, depending on climatic conditions, in the case of ventilated toilets, because of the fact that some evaporation occurs. When bucket toilets (peat toilets in particular) are used and when the sewage is composted together with household garbage on the individual

plots of collective farms, the sewage does not have to be removed.

G. G. Shigorin recommends that the following design criteria be used with respect to slops:

a. 2,000 liters per person per year (with no age factor) with respect to the volume of slops produced;

b. 2,000 liters per person per year with repect to the removal of slops from impermeable waste pits;

c. 200 to 600 liters per year with respect to the removal of slops from permeable waste pits.

Example. Six hundred persons reside in the unserviced section of a community. The section has an area of 10 hectares. Survey data indicates that 100 persons use outdoor toilets with impermeable receptacles, and that the balance of the population disposes of their sewage locally (composting, destruction by frost, etc.). Impermeable waste pits are used for the slops from 200 persons, the balance disposing of their slops by other means, such as on kitchen gardens. The amount of fluid wastes which must be transported to waste discharge stations by cesspit evacuators is to be determined.

The amount of fluid wastes is computed as recommended by G. G. Shigorin:

a. The amount of sewage will be:

S = 600 Kilograms x 100 persons + 600 Kilograms x 300 persons x 0.75 = 195,000 kilograms;

b. The amount of slops will be:

B = 2,000 liters x 200 persons = 400,000 kilograms.

c. The total volume of wastes to be removed will be:

195,000 + 400,000 = 595,000 kilograms.

Waste Discharge Points

Waste discharge points are constructed as a temporary measure pending the construction of waste discharge stations or a centralized sewage collection system.

The following requirements should be met in designing waste discharge points:

a. Observance of sanitary rules during working operations;

b. Protection of the sewage collection system against blockages.

A waste discharge station of the simplest type (Fig. 44) consists of an inspection manhole on the street sewage collection system equipped with a detachable, cylindrical screen with spaces between bars of from 15 to 20 centimeters. Such installations are employed when wastes have a water content of 95% or more and when the manhole is located away from arterial sewage lines.

Waste discharge points with special manholes (Fig. 45) are superior installations. In this case the fluid wastes are discharged through the screen of a special independent manhole (Б) which is connected to the sewage collection system by a pipe with a diameter of from 150 to 200 millimeters. The connecting pipe controls the flow of fluid wastes into the sewage collection system and provides a certain guarantee against blockages and subsequent heating of street sewers. A crater-shaped unloading area is constructed around the waste discharge point area in such cases; this permits the discharge of fluid wastes even without the use of a flexible discharge hose (Fig. 46). Paving details for the crater-shaped area are given in O.S.T. 7734.

Waste Discharge Points With Screen and Sedimentation Chamber (Fig. 47)

This installation is superior to the two described above. The sediment chamber is connected to the sewage collection system by a pipe from 150 to 200 millimeters in diameter laid at a slope greater than 0.01. The wastes are discharged into section (a) of the chamber (up to the screen (b) which retains coarse particles). Retained wastes are moved to the horizontal screen (B). Small particles are deposited in the settling section of the chamber (г). It is recommended that deposited material be removed from the chamber daily and that the chamber be washed daily. A water supply must be provided for washing the chamber. The washwater is discharged through the connection (d) which is frequently closed by the shield (ж) when the chamber is being used.

Sites selected for waste discharge points must satisfy the State Sanitary Inspection Organization. They should be at a sufficient distance from living quarters and situated on vacant lots near warehouses and preferably close to planted trees and shrubbery.

Waste Discharge Stations (Fig. 48)

Fluid wastes are discharged into a sewage collection system at these sanitary engineering installations. The design and subsequent operation of waste discharge stations should be guided by G.O.S.T. 3176-46 and by Sanitary Regulations No. 197-55 approved by the State Sanitary Inspection Organization on November 4, 1955.

Waste discharge stations (Fig. 48) are made up of a

receiving (unloading) section (1), screens (2), sand traps (3) and storage space and washing receptacles (4). Administration, personnel and auxiliary sections are also provided.

The section in which the fluid wastes are first received is designed with one, two or several receiving points. The waste discharge station shown on Fig. 48 has two receiving points (discharge channels). Large solid bodies and sand are retained by the screens and the sand traps. During the cleaning operation, wastes from the screens and deposited material from the sand trap are placed in receptacles (tanks) which are stored in the area (4). The receptacles containing the wastes are transported to treatment works. The auxiliary section contains a boiler (6) and a coal bin (5) for nothern regions, a pump (7) which creates the pressure required by the washwater tanks and installations for washing wastes on the waste discharge station premises, drying facilities for work clothes (8), and personnel premises (12) and (13). Minimum fluid waste discharges which enter the sewage collection system when a cesspit evacuator is being emptied are given on Table 24.

Note. The full capacities of pneumatically-loading cesspit evacuators given in Appendix 6 were used in the preparation of Table 24.

Table 24

Type of Cesspit Evacuator	Full Capacity Liters	Time at Waste Discharge Station Minutes	Emptying Time Seconds	Fluid Waste Discharge Liters Per Second
Pneumatically-Loading Cesspit Evacuators	2,500	8	120	21.0
	2,300	8	118	19.5
	2,100	7	110	19.0
Tanker, As Above	2,400	11	180	13.4
	1,200	10	100	12.0
Pneumatically-Loading Fluid Tank				
Two-Horse	600 - 1,000	8	90	6.7 - 11.1
One-Horse	300 - 500	7	60	5.0 - 8.3
Tanker, As Above				
Two-Horse	600 - 1,000	11	150	4.0 - 6.7
One-Horse	300 - 500	10	100	3.0 - 5.0

The receiving installation in the waste discharge channel is designed as:

a. An open crater-shaped area (for pneumatic cesspit evacuators);

b. A removable, flexible sleeve which can be attached to the outlet aperture of any cesspit evacuator;

c. A discharge manhole built into the floor and provided with a metal cover.

The wastes are diluted with water when the transporting vehicles are emptied so that they will flow normally through the waste discharge station and the sewage collection system. The wastes are diluted by 100% of the amount of wastes received when transporting units are provided with pneumatic equipment and by 300% of the amount of wastes received in the case of fluid tanks. The velocity of the wastes in the channel containing the screens and the sand trap is taken as not less than one meter per second.

The hourly discharge of one waste discharge corridor with mixed flow is computed from the formula:

$$Q_h = \frac{1}{1.3(P_1/a + P_2/b +, \ldots)} ,$$

where

P - Amount of wastes delivered by a pneumatic unit (with the assumed tank capacity), in % of total amount;

P - Amount of wastes delivered by a fluid tank (with the assumed tank capacity), in % of total amount;

a - Maximum hourly discharge of one waste discharge channel when a pneumatic unit of the corresponding capacity is being unloaded;

b - Maximum hourly discharge of one waste discharge channel when a fluid tank unit of the corresponding capacity is being unloaded;

1.3 - Ratio of maximum to average delivery of wastes.

Example. Three hundred thousand kilograms of wastes are delivered to a waste discharge station during two work shifts of a cesspit evacuator (16 hours). Seventy percent of this figure is delivered by vehicles provided with pneumatic equipment and 30 percent by fluid tanks drawn by horses. The former units are model Ts.N.-15 with tank capacities of 2,500 liters; the latter units are tanks with capacities of 1,000 liters drawn by two horses. The required number of waste discharge channels in the waste discharge station must be computed.

The average hourly flow of wastes through the waste discharge station is

$$300{,}000/16 = 18{,}800 \text{ kilograms per hour.}$$

The maximum hourly discharge of one receiving point when the tank of the former unit described above is being emptied is

$$a = (60/8)2.5 \times 1{,}000 = 18{,}700 \text{ kilograms,}$$

where

60 - Number of minutes in an hour;

8 - Time tank remains in waste discharge station, in minutes;

2.5- Capacity of tank, in cubic meters.

The maximum hourly discharge of one receiving point when a fluid tank with a capacity of 1,000 liters is being emptied is

$$b = (60/11)1.0 \times 1,000 = 5,400 \text{ kilograms.}$$

The discharge capacity of one receiving point when wastes (combined) are being removed will be

$$Q_h = \frac{1}{1.3(0.70/18,700 + 0.30/5,400)} = 8,300 \text{ kilograms per hour.}$$

The required number of receiving points is equal to 18.8/8.3 = 2.8, that is, 2 - 3 points are required under the given conditions.

Screens. According to G.O.S.T.u., the screens of waste discharge stations should be installed with spaces of from 30 to 40 millimeters between bars. Operational experience with fixed screens indicates that these figures should be related to the diameter of the sewer into which the wastes from the waste discharge station are discharged.

G. G. Shigorin recommends that the spaces between bars be from 20 to 25 millimeters when the sewer diameter is less than 400 millimeters and from 70 to 100 millimeters when the sewer diameter is greater than 600 millimeters.

Two types of screens can be used in waste discharge stations.

1. Manually-cleaned screens;
2. Mechanically-cleaned screens.

A simpler type of manually-cleaned screen is illustrated on Fig. 49. The installation of manually-cleaned screens can be recommended for waste discharge stations with one channel. It is recommended that wastes retained on the screens be ground so that it is not necessary to remove them from the stations; suitable grinders are installed in the station.

The special feature of the mechanically-cleaned screens designed by M. V. Leshchinsk (Fig. 50) is that the rake which cleans the screen is situated under the screen and is moved by an endless chain. This design can be recommended for waste discharge stations because of its simplicity and economy (consumes from 0.25 to 0.40 kilowatts when functioning).

As regards the design of the supply channel and the screen head losses, velocities of 0.7 meters per second in front of the screens and not more than 0.8 meters per second in the space between the bars are recommended. When screens are manually-cleaned, the area between the bars must be not less than twice the effective flow cross section in the supply channel; when screens are mechanically-cleaned the area between the bars must be not less than 1.2 times the effective flow cross section in the supply channel.

The head loss, h, created by the screen is computed from a suitable formula.

Sand Traps Experience indicates that from 3.3 to 8.3 liters of suspended matter (sand and other foreign bodies) per person per year settle in the sand traps of waste discharge stations. Fig. 51 illustrates the variation in the amount of

suspended matter in fluid wastes as the latter flow through the various sections of a waste discharge station (according to P. E. Bogomazov).

Sand traps installed in waste discharge station should be designed by the A. A. Karpinsk method which is similar to the practical design method given in a sewerage course.

Material deposited in a sand trap must be removed by mechanical means; the following methods can be utilized in this respect:

a. Evacuation by pneumatic cesspit evacuators or special Iloses;

b. Removal by scrapers (self-contained or mounted on an endless chain);

c. Removal by a grab bucket;

d. Removal by pumps.

Many harmful, foul-smelling gases (hydrogen sulphide, ammonia and others) are liberated when fluid wastes flow through waste discharge stations.

The maximum permissible concentrations of these gases in the waste discharge station premises are 0.02 milligrams per liter for ammonia and 0.01 milligrams per liter for hydrogen sulphide. An inflow-exhaust ventilation system is thus necessary in a waste discharge station. As seen from Table 25, the air ejected from a waste discharge station by the ventilation system highly contaminates the air in the surrounding district.

Table 25 - Data on Contamination of Outside Air Near Waste Discharge Stations

Distance from Waste Discharge Station (in Meters)	Concentrations of Contamination Gases in Outside Air Near Waste Discharge Stations (in Milligrams per liter)			
	Station No. 1		Station No. 2	
	NH_3	H_2S	NH_3	H_2S
Up to 5	-	-	-	0.209- 0.147
Up to 10	0.44	0.02 - 0.295	0.65 - 0.42	0.08 - 0.074
From 10 to 20	0 - 0.1	0 - 0.057	0 - 0.05	0.04 - 0.059
From 20 to 200	0 - 0.075	0 - 0.047	0 - 0.17	0 - 0.021

The extreme limit of the maximum permissible concentrating of gases in the air in residential areas is 0.05 milligrams per cubic meter for hydrogen sulphide and 0.1 milligrams per cubic meter for ammonia.

The following measures are taken to reduce the harmful effects of contaminated air ejected into the surrounding atmosphere by the exhaust ventilation systems of waste discharge stations:

a. Ejection of the impure air as high as possible above the ground surface;

b. Combustion of the impure air;

c. Absorption of the impure air by activated carbon;

d. Cleaning of the impure air by chemical methods.

The selection of a site for a waste discharge station is based upon local conditions; the site must conform to sanitary and hygienic requirements established for similar types of installations. G.O.S.T. 3167-46 is used in the determination of the area of the station plot. This area must not be less than:

a. 0.5 hectares for one or two receiving points;

b. 0.75 hectares for three, four, five or six receiving points;

c. 1 hectare for seven, eight, nine or ten receiving points. According to sanitary rules for the design of industrial enterprises (N 101-54), a distance of 300 meters is provided between waste discharge stations and living premises and food establishments.

The construction of waste discharge stations greatly reduces the distances which fluid wastes must be transported; the stations are therefore an economically expedient method in a number of cases.

According to data by L. M. Gusev, the cost of transporting 1,000 kilograms a distance of 6 kilometers in a cesspit evacuator with pneumatic loading and a capacity of 2,200 liters is 18 roubles. For distances of up to 3 kilometers the transport cost is reduced to 13 roubles. Other authors also point out the significant reduction in transport cost with a reduction in distance. It is thus very important to correctly determine the mean distance from the serviced region to the waste discharge station when selecting the waste discharge station site.

R. N. Zel'dovich has proposed that this mean distance be computed in the following manner. A grid is drawn on a plan of the zone in which fluid wastes are to be collected; each square of the grid has an area, F, equal to from 500 to 2,000 square meter. Knowing the population density (p persons per hectare) and the calculated amount of wastes per person, A, the amount of wastes produced in each square is computed:

$$q = ApF.$$

The area F is in hectares.

The distance from the center of each square to the waste discharge station is determined from the plan.

The following formula is used to compute the mean distance, L_m, from the above-described data:

$$L_m = \frac{(q_1 l_1 + q_2 l_2 + \ldots + q_n l_n)}{q_1 + q_2 + \ldots + q_n}$$

where

$q_1, q_2, \ldots q_n$ - Amount of sewage in each square, in kilograms;

$l_1, l_2, \ldots l_n$ - Distance from the center of each square to the waste discharge station, in kilometers.

When designing a waste discharge station it is recommended that several sites be selected and that techno-economic analyses of different alternatives be made.

Five waste discharge stations are in operation in the system of the Moscow City Trust for Residential Sanitation and Reservoir Operation; these stations received 1,321,500 cubic meters of liquid wastes in 1954 and 1,311,200 cubic meters of wastes during 11 months of 1955. The relative cost was 1 rouble 42 kopeks per cubic meter in 1955.

Requirements for a Sewage Collection System Receiving Fluid Wastes

In "Technical Instructions for the Use of a Sewage Collection System for Receiving Sewage and Melted Snow", published by the M.K.Kh. of the Russian Soviet Federated Socialist Republic in 1943, the discharge of fluid wastes into sewage collection systems is permitted under the following conditions: the diameter of the sewer must be not less than 200 millimeters, as a rule; the velocity of the sewage in the sewer must be not less than 0.7 meters

per second; and the sewer must be half full.

It is recommended here that the waste discharge station be connected to the sewage collection system manholes by a pipe with a diameter of from 250 to 300 millimeters when the velocity in it is not less than from 0.7 to 0.8 meters per second, and from 350 to 400 millimeters when the velocity in it is more than 0.9 meters per second.

Under all of the above-described conditions, the amount of fluid wastes must not exceed from 20 to 25 percent of the average sewer discharge.

Pressure Method of Transporting Fluid Wastes

When selecting a site for the construction of a waste discharge station within the boundaries of a community, planning organizations sometimes experience difficulties because of the fact that very frequently there is no sewage collection system at the point where the construction of the waste discharge station is contemplated. In such a case either a gravity sewage collection system can be installed or a pressure pipeline can be laid from the waste discharge station to a point where it is feasible to discharge the wastes. Such pressure pipelines can be called fecal pipelines, although this is not an entirely accurate designation.

In a project designed by K. D. Griboedov in 1906 for the community of Peterburg, the construction of five regional waste discharge stations was proposed with fluid wastes being pumped through pressure pipelines with a total length of 23 kilometers to a central waste discharge station from where the wastes would have to be pumped into the sea through a pressure pipeline with a

length of 7.5 kilometers.

This project was partially constructed. A screen with a diameter of 3 meters and apertures of 5 millimeters was installed in a completed waste discharge station; fluid wastes were pumped through a pipeline with a length of 4.4 kilometers and a diameter of 250 millimeters at a velocity of 0.75 meters per second.

A sixfold exchange of air was provided in the waste discharge station in the developed part of the area.

The pressure method of transporting fluid wastes, based upon the practice of pumping silt out of sewage pumping stations and upon the existing and operating fecal pipelines designed by Engineer K. D. Griboedov, can be recommended.

The practice of pumping fluid wastes from lavoratory cesspits and waste pits over short distances (up to 100 meters) via open troughs or through hoses into the nearest manholes of a sewage collection system is dealt with in the treatise by Professor A. V. Nikitin (Ref. 19). It should be noted, however, that such a method possesses important shortcomings from the sanitary point of view, and that pumping via open troughs interferes with the aesthetics of the community, even when of short duration.

The economic aspect of this method can be evaluated by examining the following data.

During two hours of work, four workers operating a pump with a capacity of 90 liters per minute pump 90 liters x 60 minutes x 2 hours = 10,800 liters = 10.8 cubic meters (10.8/4 = 2.7 cubic meters per worker) into the sewage collection system. During the same period of time, one driver makes one journey with evacuated

sewage in a fluid tank drawn by one horse and containing 0.5 cubic meters. Under these conditions the former operation is 2.7/0.5 = 5.4 times more effective than the latter.

3. Public Lavoratories

Public lavoratories are a necessary element in the sanitary facitlities of any community and must be constructed wherever people congregate. Public lavoratories must conform to all sanitary, epidemiological and technical requirements so that they are not the source of contagious diseases (intestinal and others). They must be constructed on crowded streets, squares and avenues, in parks, stadiums, stations and large stores, and at beaches and markets.

The construction of lavoratories forms part of the development plan of every city.

The capacity of public lavoratories can be fixed from the following approximate criteria:

a. Streets and squares - one toilet receptacle per 5,000 persons;

b. Parks for cultural and recreational activities - one toilet receptacle per 500 persons;

c. Stadiums - one toilet receptacle per 500 persons;

d. Beaches - one toilet necptacle per 75 persons.

The required number of public lavoratories and their distribution can be determined from the following considerations.

The territory on which the community is situated can be divided into two types of zones:

1. Blocks of occupied dwellings and public buildings with community streets and squares;

2. Zones occupied by warehouses and industrial concerns, green belts, cemeteries, etc.

For approximate computations, it can be assumed that the greatest distance to an adjacent lavoratory is 0.7 kilometers in the

first case and 1 kilometer in the second. Proceeding from this, the basic norm for a square can be taken as 0.785 d^2 which gives 0.785 x 0.7 = 0.384 square kilometers in the first case and 0.785 x 1.0 x 1.0 = 0.785 square kilometers in the second case.

The average norm for the entire populated zone is hence equal to (0.384 + 0.785)/2 = 0.585 square kilometers.

Example The required number of public lavoratories is to be determined for a city of 80,000 with a population density of 100 persons per hectares.

The area occupied by the city is 80,000/100 = 800 hectares.

The number of lavoratories required is 800/58.5 = 14.

While there are diverse solutions with respect to the design and architecture of lavoratories, they can be divided into two main types:

1. Lavoratories built as separate structures;
2. Lavoratories built in other buildings.

The first type of lavoratory (Fig. 52) is constructed on squares, in parks, at markets, etc. It has separate sections for men and women and must have an adequately pleasing architectural form. The lavoratory shown on Fig. 52 is situated in one of the parks in central Leningrad. The lavoratory is concealed by trees and shrubbery and is situated so that it can be conveniently used (Fig. 53). If it is assumed that one seat is required for each 30 men and 20 women, the lavoratory shown on Fig. 52 has a capacity of 240 persons. A sufficient number of urinals (besides the seats) are provided in the men's section.

Good ventilation must be provided in public lavoratories.

The ventilation system may be either the exhaust type or the intake-exhaust type.

Individual compartments (each containing one toilet) are built in public laboratories, as a rule. The compartments have a width of from 0.70 to 0.85 meters and a depth of from 1.15 to 1.50 meters (in plan) to permit convenient use and maintenance (sweeping, washing and polishing). In order to permit the free circulation of air, the bottoms of the partitions between compartments should be from 0.25 to 0.30 meters above the floor and the tops should not extend to the ceiling. The walls and doors of the compartments are made approximately 1.8 meters high and must be constructed from materials which can be washed with water and which are not subject to rotting, warping, etc.

Fig. 55 presents a plan of a lavoratory for 100 women and 120 men built inside an inhabited building.

The interior arrangement of such lavoratories depends on the dimensions of the section set aside for its construction.

The width of the men's section of the lavoratory is frequently greater than the width of the women's section because of the fact that urinals are installed in the former section. When single toilets are installed it is recommended that the men's section be from 3.40 to 3.50 meters wide and the women's section from 2.70 to 2.80 meters wide.

Public lavoratories are divided into superior and standard types as regards the facilities provided.

Lavoratories of the superior type are generally provided with an entrance hall, men's and women's sections, shoe shining

facilities, rooms for service personnel, a storeroom, a ventilation chamber and a boiler. Lavatories of the standard type contain men's and women's sections, rooms for service personnel and a storeroom.

When designing public lavatories, the average area required for one sanitary fixture and the dimensions of these fixtures should be determined on the basis of the data in Tables 26 and 27.

Table 26 - Average Area Required for the Installation of One Sanitary Fixture, in Square Meters

Type of Lavatory	Superior-Type Lavatories	Standard-Type Lavatories
Lavatory with Open and Closed Compartments Connected to a Sewage Collection System	8.5 - 10.5	4.5 - 5.0
Lavatories with Open Compartments Not Connected to a Sewage Collection System	-	3.0 - 3.5

Table 27 - Dimensions of Sanitary Fixtures (Including the Space Utilized by Them)

Sanitary Fixture	Width (Along Wall) Meters	Length (From Wall) Meters	Total Area Square Meters
Toilet in Closed Compartment	0.9 - 1.0	1.4	1.3 - 1.4
Toilet in Open Compartment	0.9 - 1.0	1.2	1.1 - 1.2
Bracket or Trough Urinal	0.6 - 0.8	0.9	0.5 - 0.7
Wash Basins	0.9	1.0	0.9
Compartments with Toilet, Wash Basin and Coat Hook	1.5	2.0	3.0

Public lavatory premises should satisfy the following specifications. The floor is made waterproof and is covered with

a metal or cement surface. The floor is given a slope of from 0.02 to 0.025 and traps are provided so that fluids on the floor may run off and escape. It is advisable to slope the floor from the passageways towards the walls and to install collecting channels along the walls. Traps can also be installed at the ends of the compartments. The walls are made of a material which is not subject to rotting and which does not absorb moisture. The lower parts of the walls, to a height of from 1.5 to 1.6 meters, are covered with a polished, light-colored finishing material. The lavoratory must have natural lighting with a window area equal to from 10 to 12% of the floor area.

The temperature in the lavoratory premises during the cold period of the year must be maintained at not less than +15 degrees C.

Questions concerning the techno-sanitary equipment inside public lavoratories are not examined here as this subject is dealt with in special treatises.

Mobile Public Lavoratories

Lavoratories of this type are employed at places at which the public congregates once only or periodically and at which there are no permanent lavoratories. Mobile lavoratories are built on four-wheeled trailers and have special bodies and equipment. They are towed by trucks. A temporary cesspit is constructed when there is no sewage collection system at the point at which the mobile lavoratory is placed. A new series of mobile public toilets was produced in Moscow in 1950. The design and finish of the body

and the design of the operating parts (Fig.56) of these units were superior to those of earlier units. The details of the Z.I.L.-150 truck, with several modernizations, are utilized in order to mass-produce the units.

Recent Developments

In September of 1954 the Executive Committee of the Moscow Soviet made a decision to construct 190 public lavoratories in 1956-57.

In order to successfully execute this plan, the Mospreekt Design Office developed three types of public toilets and the Mosgorispolkom Architectectural Planning Board prepared a plan for their distribution within the city.

In modern times questions concerning the distribution and appearance of new public lavoratories are decided during the development of plans for community sanitary facilities.

END OF CHAPTER 3

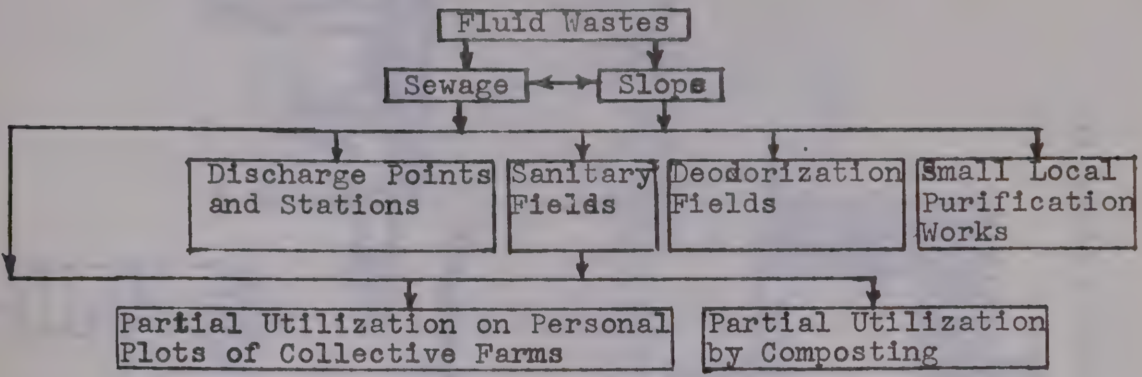
Fluid Wastes
Sewage
Slops
Discharge Points and Stations
Sanitary Fields
Deodorization Fields
Small Local Purification Works
Partial Utilization on Personal Plots of Collective Farms
Partial Utilization by Composting

Fig. 35. Chart of Installations and Methods of Purification and Utilization of Fluid Wastes

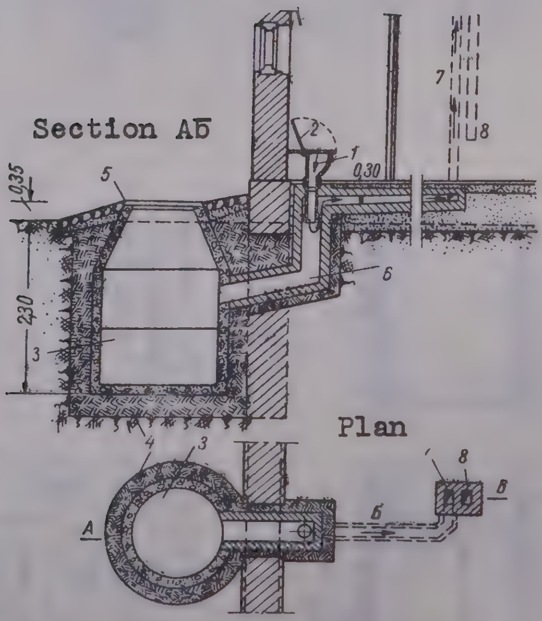

Fig. 36. Ventilated Toilet with Cesspit

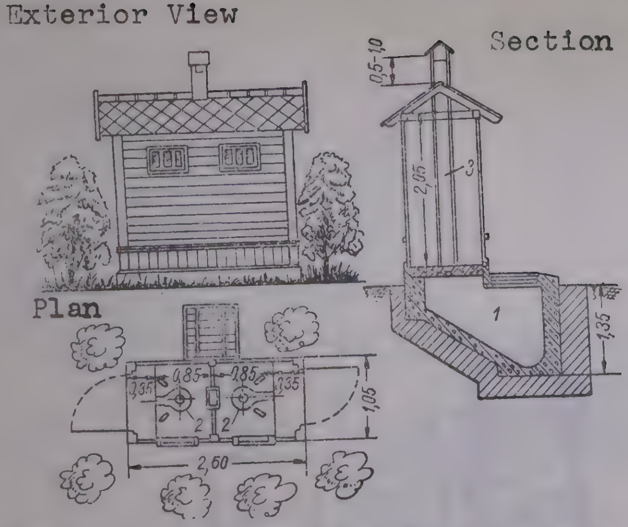

Fig. 37. Outdoor Toilet with Two Holes and Cesspit: 1. Cesspit; 2. Toilet Facilities; 3. Vent.

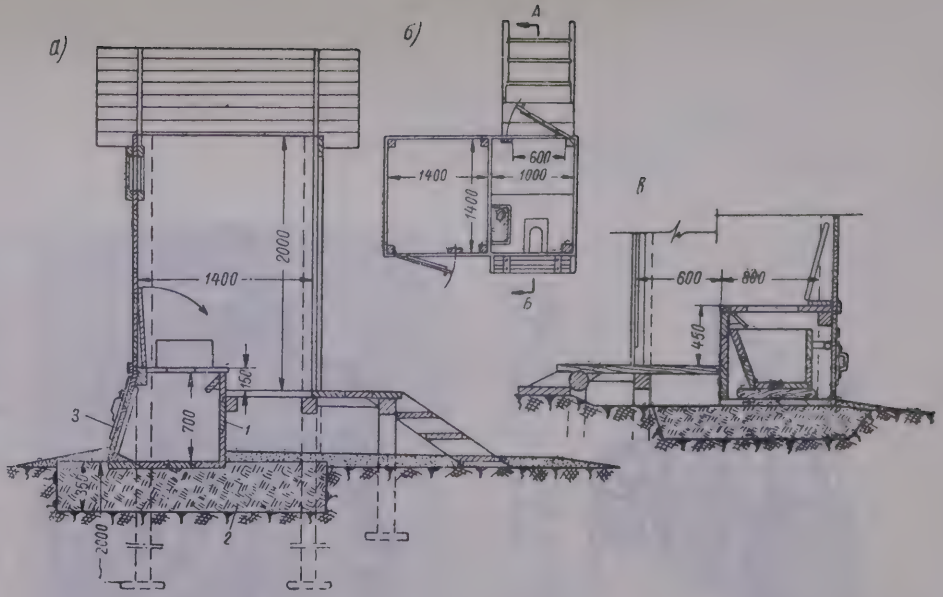

Fig. 39. Outdoor Toilet: a. & Б. Plan and Section of Toilet with Stationary Receptacle; B. Toilet with Sliding Receptacle

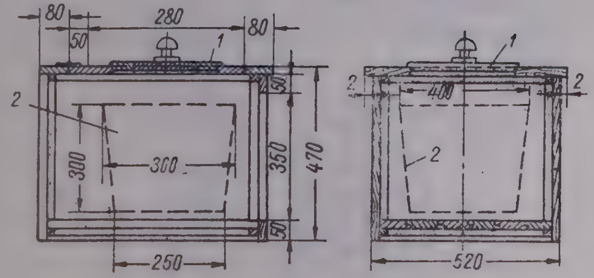

Fig. 38. Bucket Toilet: 1. Detachable Lid; 2. Removable Bucket.

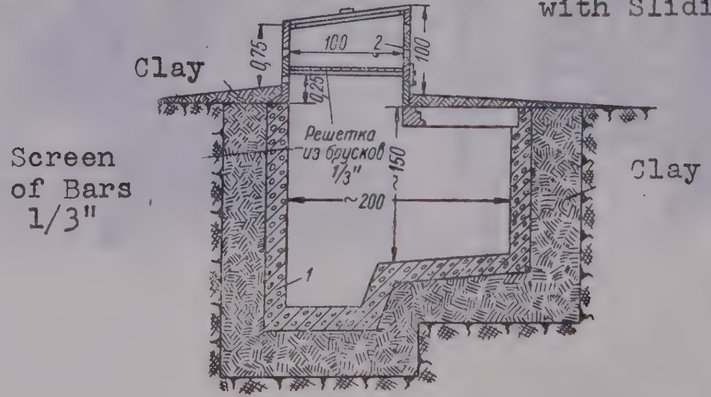

Fig. 40. Concrete Waste Pit

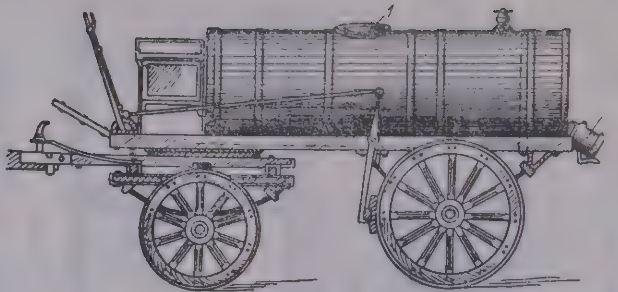

Fig. 41. Fluid Tank for Sewage Removal: 1. Upper Hatch; 2. Lower Hatch.

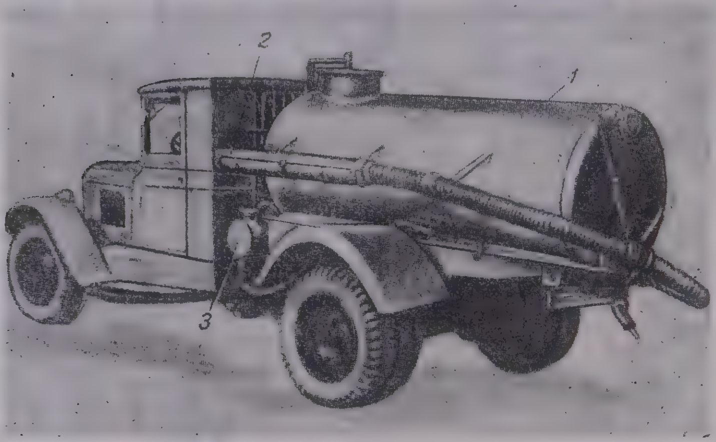

Fig. 42. Cesspit Evacuator: 1. Tank; 2. Intake Hose; 3. Vacuum Pump.

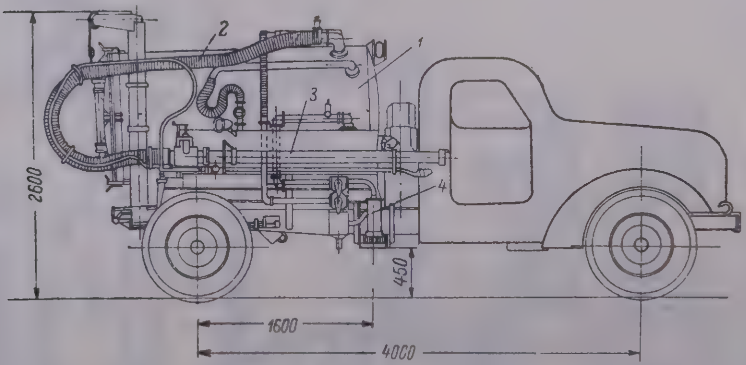

Fig. 43. General View of the Ilosos I.L.-Z.I.L.-585 Model L.N.I.I. A.K.Kh.

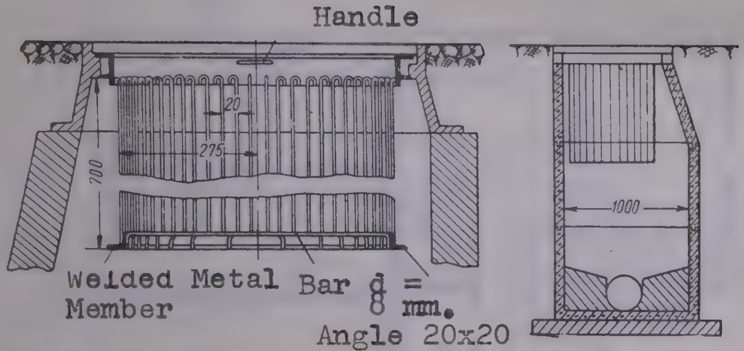

Fig. 44. Simpler Type of Discharge Point: a. Detail of Metal Screen; b. Manhole with Screen.

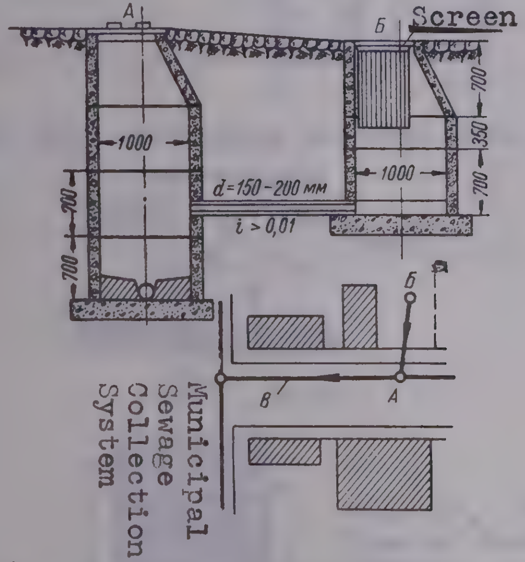

Fig. 45. Discharge Point with Special Manhole to Receive Fluid Wastes: A. Manhole of the Municipal Sewage Collection System; Б. Manhole without Settling Basin; B. Connecting Conduit.

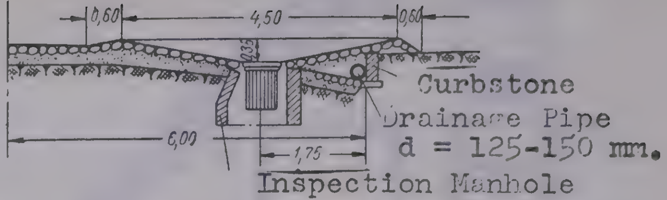

Fig. 46. Discharge Point with Crater-Shaped Discharge Area

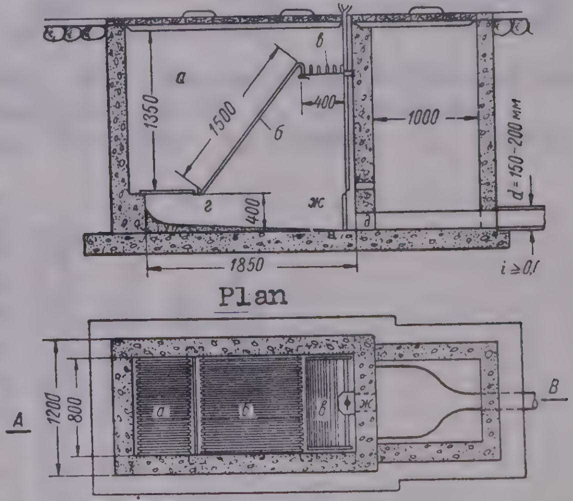

Fig. 47. Discharge Point with Screen and Sediment Chamber

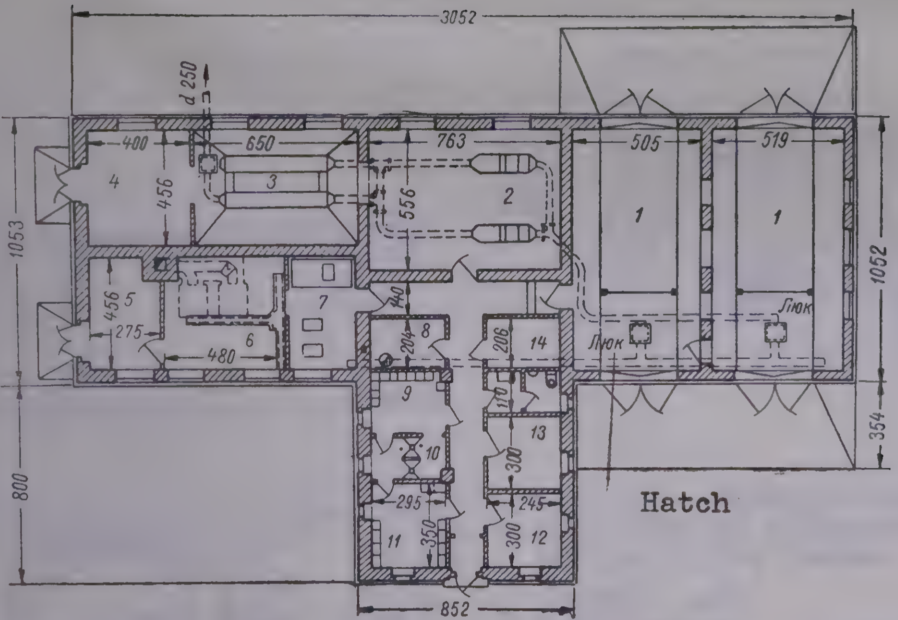

Fig. 48. Discharge Station with Two Receiving Points

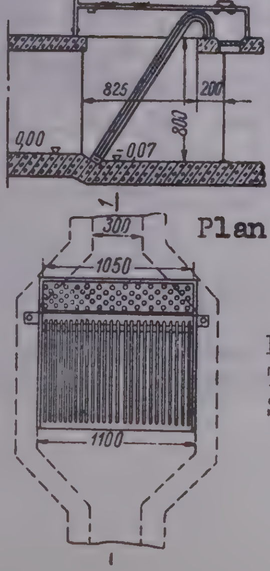

Fig. 49. Simpler Type of Hand-Cleaned Screen

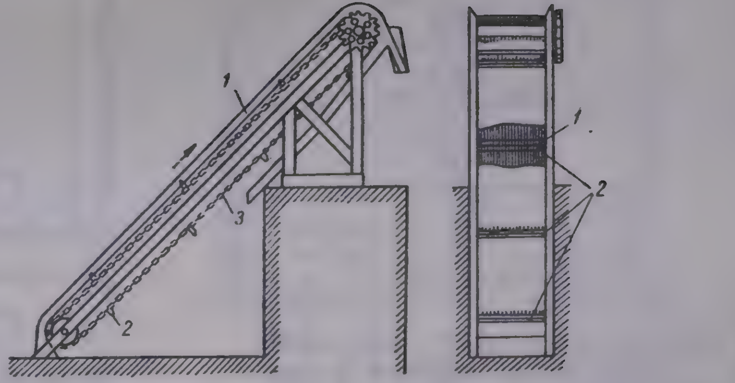

Fig. 50. Mechanically-Cleaned Screen Designed by M. V. Leshchinsk:
1. Screen; 2. Rake; 3. Chain.

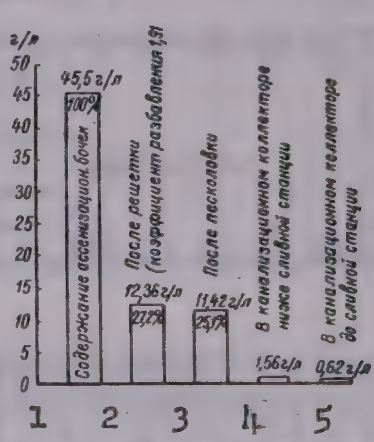

Fig. 51. Graph of the Change in Suspended Material with its Passage Through the Various Sections of a Discharge Station: г/л - Grams per Litre;
1. Contents of Cesspit Evacuator Tank; 2. Downstream from Screens (Dilution Coefficient 1.91);
3. Downstream from Sand Trap; 4. In Sewage Collection System Downstream from Discharge Station;
5. In Sewage Collection Upstream from Disch. Sta.

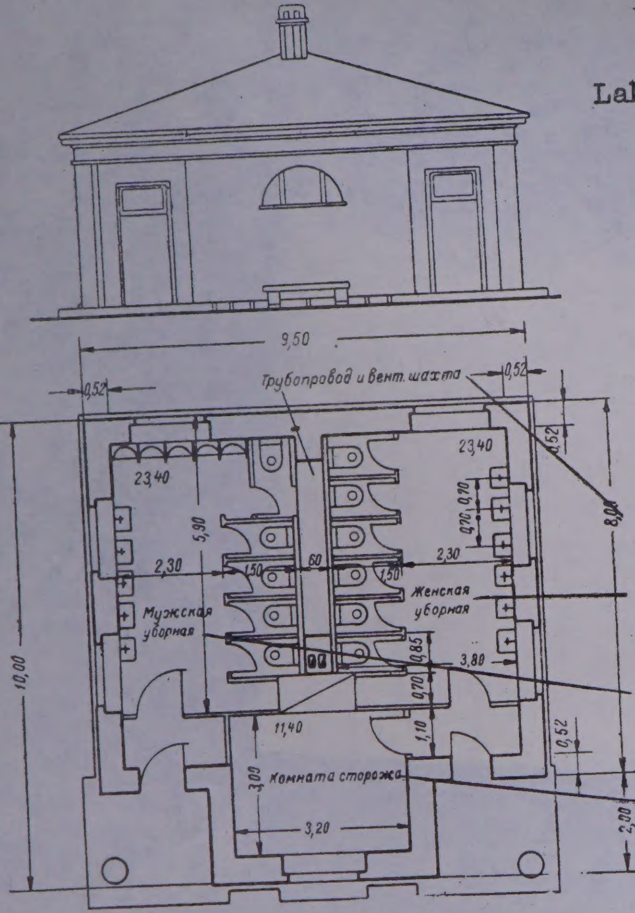

Fig. 52. Plan and Elevation of a Public Lavoratory in a Separate Pavillion

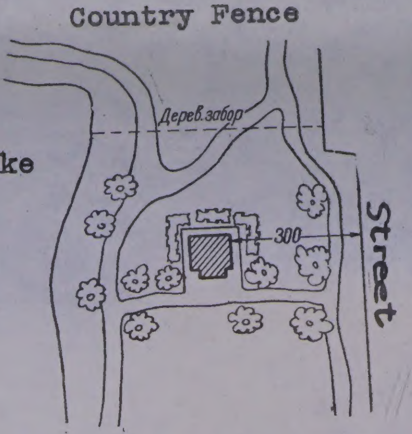

Fig. 53. General Location Plan of a Lavoratory in a City Garden

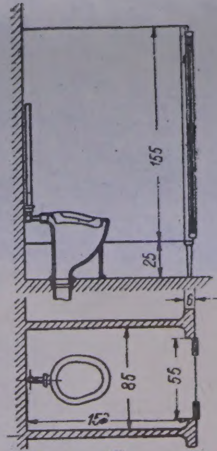

Fig. 54. Compartiment in a Public Lavoratory

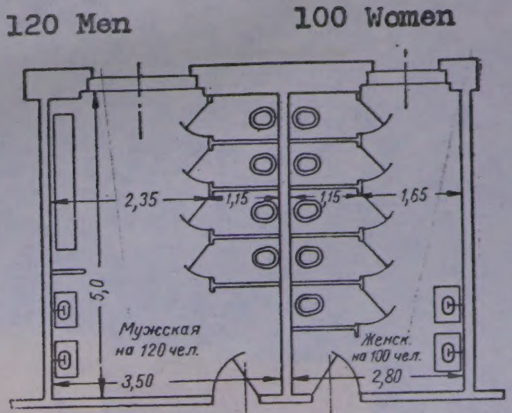

Fig. 55. Plan of a Permanent Public Lavoratory for 100 Women and 120 Men

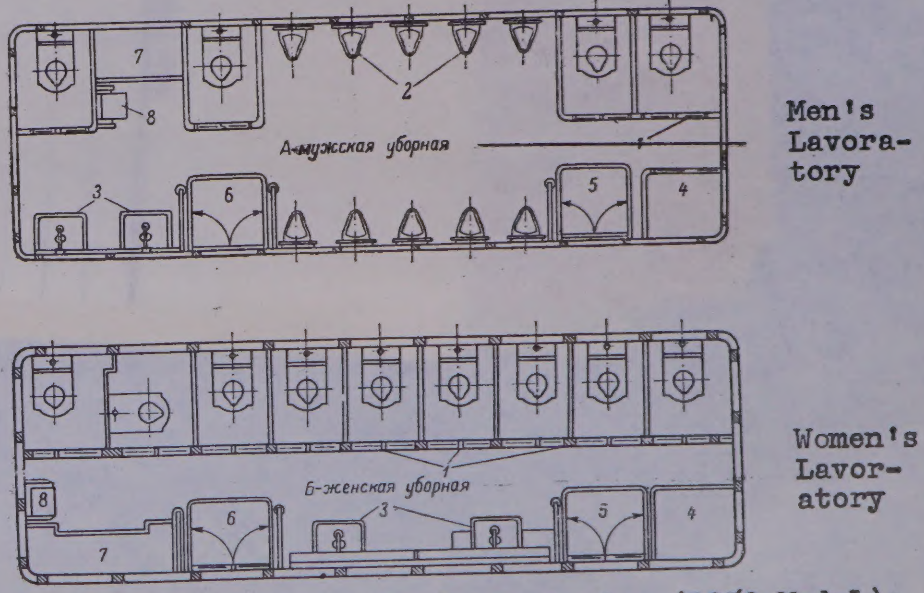

Fig. 56. Plan of Mobile Lavoratories (1950 Model):
1. Compartments; 2. Urinals; 3. Wash Basins;
4. Maintenance Compartment; 5. Entrance;
6. Exit; 7. Cabinet; 8. Folding Seat.

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